TESTING A PERCEPTUAL PHENOMENON: P1

Introduction

In a Stroop task, participants are presented with a list of words, with each word displayed in a color of ink. The participants task is to say out loud the color of the ink in which the word is printed. The task has two conditions: a congruent words condition, and an incongruent words condition. In the congruent words condition, the words being displayed are color words whose names match the colors in which they are printed: for example RED, BLUE. In the incongruent words condition, the words displayed are color words whose names do not match the colors in which they are printed: for example PURPLE,ORANGE. In each case, we measure the time it takes to name the ink colors in equally-sized lists. Each participant will go through and record a time from each condition.

Investigate the Dataset

We have been given the data set; `stroopdata.csv`. It contains the timing for each subject. Here is a snapshot of the data set:

```
stroop <- read.csv('stroopdata.csv')
head(stroop)
```

```
 Congruent Incongruent
1    12.079      19.278
2    16.791      18.741
3     9.564      21.214
4     8.630      15.687
5    14.669      22.803
6    12.238      20.878
```

It is easy to notice from figure 1, that most of the subjects are slower while reading incongruent words. There are few subjects, that are comparatively slower in reading incongruent words as compared to other subjects. Notice the positive correlation between the reading times. The subjects who are slow in reading congruent words, take relatively longer time to read incongruent words, as compared to their counterparts in the sample.

```
p <- ggplot(stroop, aes(x=Congruent, y=Incongruent))
p+geom_point()+labs(title='Congruent vs. Incongruent')
```

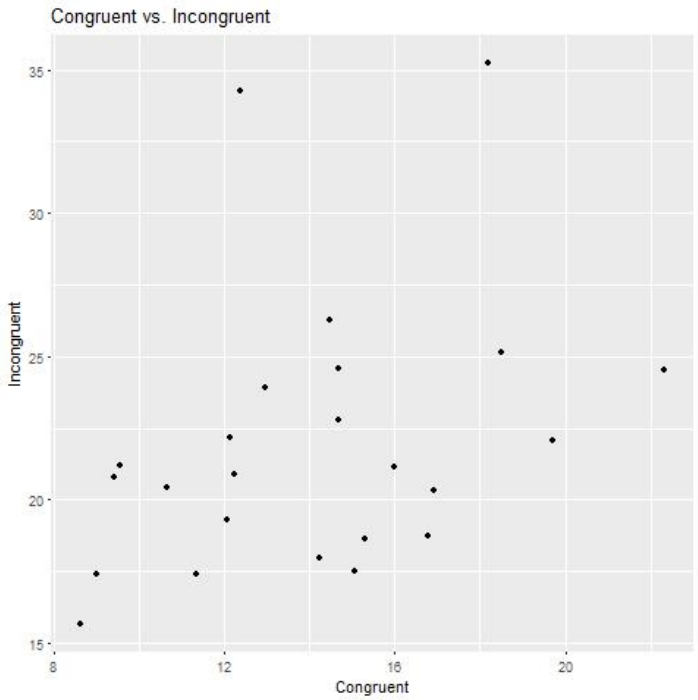

Figure 1: Scatter plot for congruent vs. incongruent times

The goal is to check whether the mean reading time for congruent words for the entire population is same as mean reading time for incongruent words for the population. To this end, we do Hypothesis testing. Since, same subject is being used for two different tests, we have dependent samples. Here, we have multiple pairs of observations, with each pair representing the two different reading times for each subject. Therefore, it is an example of paired t-test.

For analysis purpose, we define a new column; `diff_read`, which accounts for the difference in the reading speed.

```
stroop$diff_read <- stroop$Incongruent-stroop$Congruent
```

```
> head(stroop)
  Congruent Incongruent diff_read
1    12.079      19.278     7.199
2    16.791      18.741     1.950
3     9.564      21.214    11.650
4     8.630      15.687     7.057
5    14.669      22.803     8.134
6    12.238      20.878     8.640
```

Here, the dependent variable is the reading time for each subject. The independent variable is type of words, a categorical variable with two levels; congruent and incongruent. Next, we state the null and alternate hypotheses for this case.

$$\text{Null Hypothesis} : H_0 : \mu_{diff} = 0$$

Alternate Hypothesis : $H_a : \mu_{diff} \neq 0$

.
where μ_{diff} represents the difference between mean of reading time while reading congruent words and mean of reading time for incongruent words over the entire population.

In words, the null hypothesis states that, the population mean reading time for congruent words is same as population mean reading time for incongruent words. The alternate hypothesis states that these means will not be identical. Since the population standard deviations are not known, we use t-test. Moreover, the distribution of the variable `diff_read` is roughly normal, see figure 2. It is slightly right skewed. Therefore, t-test seems to be a suitable choice. Moreover, since we have related subjects, we will use paired t-test in R.

```
%plot the histogram for diff_read
ggplot(stroop, aes(x=diff_read)) +
geom_histogram(breaks=seq(0, 22, by = 2),
                 col="red",
                 fill="green") +
  labs(title="Histogram for Difference")
```

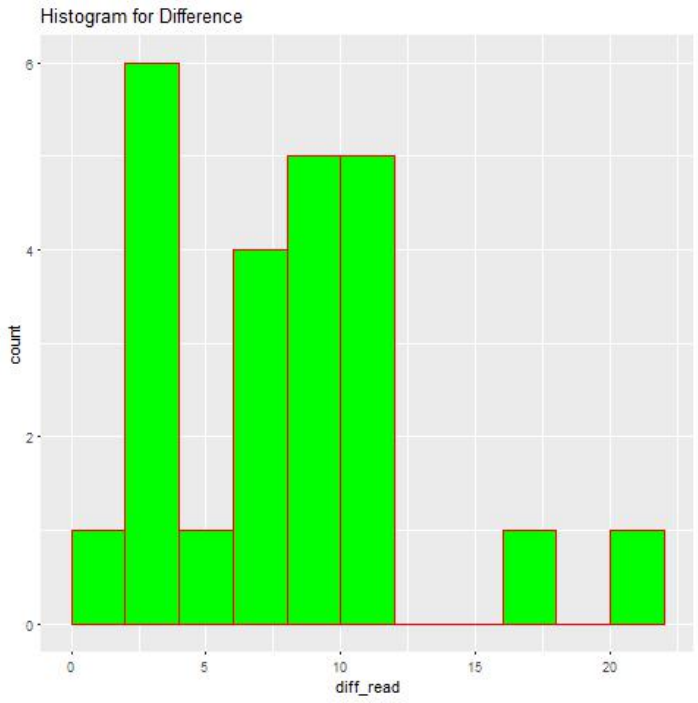

Figure 2: Distribution of the difference in reading speeds

Descriptive Statistics

Here, we calculate some relevant descriptive statistics for the sample data. First, we calculate the standard deviations for the three numeric variables.

```
sd_congr <- sd(stroop$Congruent)
> sd_congr
```

```
[1] 3.559358
```

```
 sd_incongr <- sd(stroop$Incongruent)
> sd_incongr
[1] 4.797057
>
sd_diff <- sd(stroop$diff_read)
> sd_diff
[1] 4.864827
```

Next, we obtain the measures of central tendency, example, mean for the above three variables.

```
summary(stroop)
   Congruent      Incongruent      diff_read
 Min.   : 8.63   Min.   :15.69   Min.   : 1.950
 1st Qu.:11.90   1st Qu.:18.72   1st Qu.: 3.646
 Median :14.36   Median :21.02   Median : 7.667
 Mean   :14.05   Mean   :22.02   Mean   : 7.965
 3rd Qu.:16.20   3rd Qu.:24.05   3rd Qu.:10.258
 Max.   :22.33   Max.   :35.26   Max.   :21.919
```

Hypothesis Testing And Conclusion

Finally, we implement the paired t-test in R. The default significance level is given by $\alpha = 0.05$. We are testing for difference in means in the alternate hypothesis, it is an example of two tailed test. Using the t table, the threshold value of the t statistic is found to be 2.069.

```
t.test(stroop$Congruent,stroop$Incongruent, paired=TRUE)
```

The results of the paired t-test are presented below.

```
data:  stroop$Congruent and stroop$Incongruent
t = -8.0207, df = 23, p-value = 4.103e-08
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -10.019028  -5.910555
```

As observed from the above results, the p-value is very small as compared to α. Therefore, we reject the null hypothesis. Hence the results are statistically significant and we conclude that the mean reading time for congruent words is different from the mean reading time for incongruent words. We can also see that 0 does not lie in the 95 percent confidence interval. This is an equivalent explanation for rejecting the null hypothesis.